How to Protect Structural Metal

HOW TO PROTECT STRUCTURAL METAL

A Practical Hand Book Upon the Mixing and Application of Paint to Iron or Steel, Tin, and Galvanized Iron, Together with a Brief Explanatory Discussion of the Causes of Corrosion and Remedies for It

NATIONAL LEAD CO.

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Difference in Paints

MISUNDERSTANDING of what paint is, what it can be reasonably expected to accomplish, and how it performs its duty in preserving and beautifying objects, is responsible for a great loss of money, both to the small property-owner and the great manufacturer.

To the average person paint is paint, and the first error to which this lack of discrimination leads is the use of the same paint for all purposes and under all conditions.

That pure white lead and pure linseed oil, mixed properly to suit the special conditions under which the paint is to be used, is the best possible protection for wood, brick and cement, cannot be gainsaid. But when it comes to the painting of a metal surface, white lead, though good, must yield first place to red lead.

To show fully just why this is so would require a long explanation of what corrosion is, a comparison of proposed methods to stop or retard it and an intricate examination of the chemical and physical properties of various materials. This would be out of place in a practical hand-book designed for the daily use of the architect, engineer and painter, such as this little booklet aims to be.

Enough of the theoretical phase of painting metal surfaces must be given, nevertheless, to satisfy the intelligent inquirer that the methods recommended are scientific.

Tendency of Metals to Corrode

The relative tendency of various metals to corrode or oxidize is shown by the following table; those which corrode most easily being placed first and those which

resist corrosion more successfully following in their order. Zinc, the most easily corroded, is thus at the top, and gold, the most resistant, at the bottom of the list.

Zinc
Aluminum
Cadmium
Iron
Steel
Nickel
Lead
Hydrogen
Copper
Mercury
Silver
Platinum
Gold

In practical affairs iron, in one form or another, is the metal principally used. By the above list it will be seen that iron is one of the most readily corroded. Our attention will be given entirely, therefore, to this metal, either bare or covered with a coating of tin or zinc.

Decay, Both Internal and External

Iron and steel, then, are subject to decay. That is to say, they are liable, under certain conditions, to lose some valuable quality which weakens them. If this loss is internal it may be caused by what is called "fatigue" due to crystallization or to loss of strength through strain. The crystallization cannot be prevented by painting. If the decay is external it is due to oxidation of the surface, i. e. the metal rusts. This can be prevented by proper painting.

Iron and steel will not rust at ordinary temperatures except in the presence of moisture; therefore, contact of water or moist air with the metal is the thing to be feared and, if possible, prevented. Water and air are known as the primary causes of corrosion. To these must be added a number of secondary causes or

accelerators of corrosion, such as, first, rust itself, because it absorbs and holds moisture to the surface; second, carbonic and other acids; third, neutral or acid salts in solution; fourth, roughness in the surface; fifth, foreign matter, such as scale, on the surface; sixth, inequalities in surface conditions due to imperfectly made metal; seventh, stray electric currents.

Methods of Preventing Rust

Rusting is a galvanic or electric action and the ill effect of all these secondary causes or accelerators of corrosion is due, in the final analysis, to electric action which they set up in the iron or steel. If we could stop the electric action produced in iron under certain conditions, there would be no corrosion and iron would become a noble metal. This can be done temporarily by immersing the iron in an alkali solution; but as soon as the iron is taken out, it rusts as before. The alkaline-solution method of preserving iron is therefore impracticable for most purposes. To use alkalies in paints is not practical because they decompose the oil and are soluble in water.

Another method by which the galvanic action can be prevented is to treat the iron with solutions of chromic acid or certain forms of concentrated nitric acid. But this treatment, also, at the present state of practice, is found to be of but temporary value, for the iron gradually returns to its original state, in which it rapidly corrodes.

Both the above methods attempt to change the *nature* of the iron itself and render it immune to galvanic action. They are interesting and some day a method may be found to render permanently effective the change which they undoubtedly make in the iron itself. But until that day comes we are compelled to leave the nature of the iron as it is and *protect it* from the causes which set up the electric action within it. In other words, we have to *paint* it. And the paint must be made of some material which will not itself *start* galvanic action by contact with iron and which

will effectually *keep out* water or other injurious elements. There are several candidates for selection as protectors of metals from corrosion. Before examining them specifically, let us observe what the requisites of a good paint for iron and steel are.

What Constitutes a Good Paint

Asking this question regarding preservative coatings for iron and steel, we find it necessary to point out that a paint which may be a good paint for the under coats may prove to be an undesirable paint for the outer or finishing coats, and vice versa. We will call the paint which is to go next to the metal the "protective paint," and the paint which comes outside, the "finishing paint." The finishing paint should be, in reality, a "protective paint" also, but, for clearness in discussion, it is necessary we should make a distinction.

The protective paint should measure up to the following

General Qualifications:

First—It should form a hard, adherent foundation for subsequent coats. There is nothing else which tends so much to the cracking, checking and alligatoring of paint as the application of relatively hard coats over relatively soft coats. This is an observation which should be kept in mind not only in the painting of metals but in all painting. That the priming coat should have the power to adhere tenaciously to the surface is self-evident.

Second—The pigment constituents of a protective paint should be inhibitive of corrosion. This means that it should tend to give passivity to the particles of the iron itself—should by its nature tend to prevent that activity of molecules which we have described as galvanic and which causes corrosion.

Third—A protective paint should be a non-conductor of electricity. The corrosion of iron and steel being the result of a galvanic action, it is necessary not only

to put on a paint which will be inhibitive, that is, keep out those influences which will set up the galvanic action in the iron itself, but it is supremely necessary also to bar the way to stray electric currents from the outside. In these days when electrically charged wires run everywhere, under the streets, overhead and through all buildings, the leakage of electric currents is an every day problem. The real solution of the problem would seem to be to confine these electric currents where they belong instead of allowing them to run riot among neighboring property. Motives of economy itself will doubtless some day lead the owners of the runaway electricity to correct this evil themselves, but until that day arrives, we must do our best to protect our property against currents which are running amuck.

Some pigments are good conductors of electricity. These should be avoided in paint intended for the protection of iron and steel.

Fourth—A protective paint should contain no compounds soluble in water. The reason for this is apparent. If any of its constituents is soluble in water, which is one of the chief enemies we are fighting, the paint will soon go to pieces under service conditions. Water-soluble compounds may also, under certain conditions, unite with other elements to form new compounds favorable to the conducting of electricity.

Fifth—A protective paint should be as impermeable as possible. This qualification scarcely needs comment. One prime purpose of a protective paint is to keep out water. If it is porous, moisture—a principal cause of the galvanic action which causes rust—will find easy entrance.

Sixth—Protective paint should vary in color in its different coats. This is one of the most important requisites of a protective paint, but one which is very often overlooked or ignored. Poor workmanship is responsible in very great part for the failure of protective coatings. Paint is often applied by cheap and inefficient labor, and if each successive coat of paint is of the same color as the preceding one, it is impossible

for an inspector to detect slighted parts.. Above all, the first coat should be very different in color from the natural color of the metal and the finishing coatings should be different from the protective coats.

Available Paints

There are several materials in more or less general use as protective paints for metals. A brief examination of the nature of these materials will enable us to see how they measure up to the standard set by the foregoing requirements.

Linseed Oil.—Linseed Oil, without a pigment, is sometimes recommended as a priming coat for iron or steel, but such a practice cannot be too emphatically condemned. Linseed oil is the best vehicle to use with a good pigment, but when used alone it fails to meet four of the important requirements given.

In the first place, linseed oil forms a film which always remains soft as compared with later coats containing pigments. The cracking and alligatoring of the subsequent paint is almost inevitable.

In the second place, linseed oil is not an inhibitor of corrosion, and it separates the iron and steel from the subsequent paints, thus nullifying any rust-inhibiting power which the later coats possess.

In the third place, it is more or less porous and, the film being thin, it is permeable.

In the fourth place, linseed oil is transparent, making it almost impossible for an inspector to tell whether or not the surface has been perfectly protected by it.

Mineral Oils.—No mineral oil or non-drying oil of any kind should be used in a protective coating. They prevent the paint from becoming sufficiently hard to give a good foundation for subsequent paint. Linseed oil, when used alone as we have seen above, makes a soft film, but when used with a pigment, especially if a part of the oil is boiled, the film will dry hard. Linseed oil, therefore, should be used with a pigment in all protective coatings.

Asphaltum.—The objection to asphaltum, which is sometimes used, is that it tends to work through all subsequent coats and never becomes sufficiently hard to give a good foundation for the later films. It thus violates requirement No. 1.

Graphite and Carbon.—These substances do not possess inhibitive qualities, and they also give to a protective coating the power to conduct electricity. They therefore violate two of the most important laws laid down for protective paints. Carbon also absorbs so much oil as to make it a mere wash. A paint in which the pigment forms only one part and the oil four parts is undoubtedly easy to spread but there cannot be much protection in the film. Finally, the similarity of color between the black graphite or carbon and the dark iron makes it difficult to detect imperfections in the application of such a paint.

Iron Oxides.—The oxides of iron would be fairly good materials to use in protective coatings provided that they were fully dehydrated and contained no sulphur compounds, especially sulphate of calcium, which in the presence of moisture is a fairly good conductor of electricity and therefore acts as an accelerator of corrosion. Theoretically good iron oxide—dehydrated and sulphur-free—is seldom seen in practical use, as results show.

Sometimes carbonate of calcium (chalk or whiting) is added to oxide-of-iron paint for the purpose of correcting the evil due to the presence of sulphur compounds; but this practice is not to be commended, for soluble calcium sulphate will then be formed, and soluble compounds, as we have seen in our list of requisites, are bad for a protective coating. The solubles help to carry moisture to the surface of the iron, and moisture sets up the galvanic action which produces corrosion. It will be seen, therefore, that the difficulty in the case of iron-oxide paints lies not so much in the inferiority of theoretic or perfect oxide of iron itself as in the fact that the iron oxides obtainable cannot be relied on as free from injurious constituents.

Red Lead's Qualifications

We now come to consider red lead and to judge it by the same standard of requirements which we have applied to the other materials.

In the first place, there is no paint which makes such a good, hard, tenacious film as red lead. For this one reason alone many painters prefer it, in spite of its color, for general painting, even of woodwork, brick, etc. Red-lead paint dries to a hard, tough layer and gives the best foundation for other painting that has been devised. Over it almost any kind of paint can be applied. It forms an especially good foundation for varnishes, varnish paints, enamel paints and all other forms of decorative painting. Over a pure linseed oil and red-lead paint there is less tendency to check and alligator. The red-lead paint adheres to the metal with a tenacity that is remarkable. When attempting to clean old metal one often finds the red lead clinging so fast that it cannot be removed even with wire brushes.

In the second place, red lead is unquestionably the most practicable inhibitor of corrosion available as a constituent of protective coatings.

In the third place, it is an excellent insulator and is practically indispensable for painting metal where electric currents are present in unusual quantity. A German scientist, writing in the *Farben Zeitung*, says: "Red lead is remarkably impervious to electricity of high tension, being fully equal to the best india-rubber or gutta-percha, as an insulating material."

In the fourth place, pure red lead mixed with pure linseed oil makes a paint which contains no constituents soluble in water. It therefore passes our fourth requirement with a perfect score.

As to the fifth requirement, impermeability, red lead stands especially high. In order to secure a great degree of impermeability each of the paint coats must have a reasonable thickness. If the paint is brushed out too thin, one or more additional coats must be applied to give proper thickness of coating. The working qualities

of red lead mixed with linseed oil are such that the film spread with it is of a superior character.

Impermeability is also affected by the amount of pigment present in the film. Generally speaking, the greater the amount of pigment, the more impermeable the paint will be. The increase of the proportion of pigment to oil must stop, of course, when the paint becomes unworkable. Red lead is noted for the large quantity of it which can be mixed with a gallon of linseed oil and still give a good working paint.

Furthermore, it has been found that the finer the pigment, the more impermeable the paint; but the fineness of the pigment must not be increased beyond what will permit the presence of the largest quantity of pigment in the paint. Red lead as we make it is an exceedingly fine, uniform pigment and yet makes a splendidly working paint at the proportion of four parts pigment to one part oil.

To recapitulate, red lead stands high on the score of impermeability because, (a) it produces a good thick film, (b) it requires a minimum of vehicle and (c) as we make it, it is a fine, uniform pigment.

The sixth requirement is met perfectly by red lead. It has the most distinctive color of any of the pigments usually employed as paints for metals. Its bright orange hue is readily distinguished from the dark gray or black of iron and steel, which makes it an admirable priming paint, considered from this point of view. An inspector can readily see whether any spots have been left uncovered. The second coat of red lead can be slightly tinted with a few ounces of lamp black, thereby rendering it distinct from the first coat. On the third coat one may return to the natural orange red of the red lead, or deepen it still further with lamp black.

What Red Lead is and How it is Made

Red lead is an oxide of lead and if of theoretical purity, contains 90.65 per cent. of lead. Its formula is Pb_3O_4 and apparently it is plumbate of lead, formed by the

combination of peroxide of lead (PbO_2) and litharge (PbO). It is a red powder varying in color from a light orange to a dark red.

Metallic lead is melted and, in the molten condition, is slowly oxidized to litharge. This litharge is a more or less yellow substance and, for the purpose of making red lead, should be as free from crystals as possible. The litharge is finely ground and then placed in a reverberatory furnace and subjected to a low red heat. At this temperature it slowly absorbs oxygen and is converted into red lead according to the following equation: $3PbO+O=Pb_3O_4$.

The oxidation of litharge to red lead is never complete; that is to say, it is almost impossible, in the present state of the art, to oxidize all of the litharge to red lead.

There is one form of red lead, using the term in its generic sense, which is made by the oxidation of white lead. This is known as orange mineral, and, on account of its original fineness and its amorphous condition, is more readily oxidized and, consequently, usually contains a lower percentage of litharge than red lead made from metallic lead.

The temperature at which litharge is manufactured is ordinarily above 1600° F. The temperature at which litharge is converted into red lead is between 900° and 1000° F. If the temperature is materially below 900°, little or no oxidation takes place. If it is materially above 1000°, the red lead gives up oxygen and is converted back into litharge.

Red Lead Should be Fine and Highly Oxidized

For painting purposes, red lead should be as fine as possible. If it is not sufficiently fine, it will tend to run when mixed with linseed oil and it will have an inferior covering power. Red lead should be oxidized as highly as is reasonably possible; that is, it would appear that a red lead which contains over 90 per cent. red lead and under 10 per cent. litharge makes the best combination for painting purposes, and the standard of quality should be placed at this figure.

The color of red lead depends to some extent upon the purity of the pig lead or other materials from which it has been made. If made from a reasonably pure pig lead it will have a bright, clean color. The difference in depth of color depends largely upon its fineness. The finer the red lead, generally speaking, the more inclined it is to an orange color. The coarser the red lead, generally speaking, the deeper will be the red color. Red lead, if finely ground and made from unvitrified stock, should to the naked eye show only occasional glistening particles.

No Mill Necessary in Mixing

In the preparation of paint by mixing red lead with linseed oil the use of a mill is unnecessary. The red lead mixes readily and can be stirred into the oil so as to obtain a suitable paint with little difficulty. It has some tendency to settle out of the oil, so that the paint should be occasionally stirred during its use.

If the red lead contains a high percentage of litharge, this litharge is apt to act on the oil, forming a lead soap and, when allowed to stand for any length of time, occasions hardening in the bottom of the keg or barrel in which it has been mixed. If, however, the red lead is finely ground and contains less than 10 per cent. of litharge, the tendency to harden is not great; so that the paint mixture containing such a red lead can be allowed to stand several days without becoming hard enough to prevent its being readily blended with the oil again.

In the preparation of red-lead paint, raw linseed oil can be used, or a mixture of raw linseed oil and boiled oil in the proportion of two of raw to one of boiled oil. It is preferable not to use any liquid drier, as that contains a volatile thinner, such as turpentine, which tends to impair the working qualities of the paint. Generally speaking, the amount of red lead to be used in the preparation of red-lead paint should be as large in proportion as possible in order to obtain the best results. Thirty-three pounds red lead to one gallon of oil is

recommended as a general proportion, although twenty-eight pounds to the gallon of oil may be found more practical under some conditions. A reduction in the amount of pigment should be made only when the circumstances of the case particularly demand it.

Red Lead's Relation to Linseed Oil

The nature of the relation between red lead and linseed oil in paint is a matter of some dispute. It is believed by some that red lead forms a cement by combining with the linseed oil. It would seem, on the other hand, that this combination only takes place in proportion to the free litharge present and not between the red lead and the linseed oil.

It appears also that much of the character of red-lead paint is given to it by the effect the red lead has upon the drying of the oil, the lead and the oil drying all the way through, while a manganese drier dries on the surface. It has been suggested that the boiled oil used with red lead should contain no manganese. This may be a good practice. It seems more likely, however, that the amount of lead present is sufficient to overcome any tendency towards surface drying given to the boiled oil when manganese is present in it.

The Uses of Red Lead

One might cover the uses of red lead as a protective paint for metals in the words: "Wherever metal is used." It may be profitable, however, to enumerate some of the more important fields in which a protective paint is required and call attention to some of the considerations peculiar to each.

Structural Iron and Steel

The architect and engineer are probably more vitally interested in the proper paint for metal work than any other class of paint users, for more serious consequences follow a mistake upon their part. Not only may vast

and other steel structures, should persuade gas companies and water companies to use the same material for painting gasometers, stand-pipes, tanks, etc.

Other paints may be had which will show lower first cost, but there is none which will maintain the plant at such a small expenditure per year. Red lead is a real preservative of iron and steel.

Metal Roofs

There is no metal used as roofing, except lead itself, which can stand the weather without being painted. Tin, galvanized iron or steel should be coated with red lead and linseed oil as hereinafter explained in detail. The roof need not be left the natural color of the red lead if that color is undesirable. If a light tint is wanted, white-lead paint tinted to any desired shade is the paint for the finishing coats; if a dull red or brown is suitable, the last red-lead coat may be toned with lamp black.

Cornices and Other Galvanized Iron Work

Galvanized iron presents difficulties in painting because the coating left on it by the galvanizing process seems to repel most paint. Red lead and linseed oil paint will stick to it better than any other material. Cornices or other parts made of galvanized iron should be allowed to weather or be treated with a special solution, as described on page 30, before painting. Red lead paint should then be applied as to iron.

Interior Metal Work

Steam radiators, registers, pipes, grilles, water-tanks and every piece of exposed metal work inside of a building should be painted first with red-lead paint, then finished with white lead and linseed oil, tinted to suit the color scheme of the room.

Fire Escapes, Fences, Etc.

Fire escapes, fences, iron gates, grilles and ornamental exterior metal work of all kinds should be painted with red lead and linseed oil.

Red Lead in the Factory

Besides its use on the structural members of the building itself, the contents of a factory frequently require red-lead paint. Machinery, trucks, iron pipes, tanks, etc., on the interior, and smoke-stacks, stand-pipes, conveying machinery, derricks, etc., out-of-doors, should be painted with pure red lead first and finished with red lead toned with lamp black or with whatever finishing paint best suits the conditions.

For Steel Cars

For steel cars red lead is the ideal paint, not only because of its general anti-rust qualities but because it makes a hard film which resists in a superior way the friction and hard knocks to which such cars are subjected.

Painting of Steel Ships and Boats

Nowhere has red lead proved itself more of a property-preserver and money-saver than in the painting of the hulls of steel ships and other metal parts of such craft. From the United States Government to the maker of the smallest craft, vesselmen are constant users of red lead in enormous quantities. Whether on salt water or the great inland seas, red lead stands out as the great ship paint. Many proofs of the truth of this statement could be adduced, but none stronger than the fact that marine insurance companies practically condemn all but red-lead-protected vessels by charging a much higher rate for those from which red-lead protection has been omitted.

The hulls, cargo holds, coal bunkers, chain lockers and, in fact, all metal parts of ships should be painted with red lead as hereinafter described.

sums of money be lost through the imperfect protection of the iron and steel skeletons of their structures, but human life itself hangs upon the proper preservation of those great steel frames.

An architect or an engineer may correctly figure the stress and strain, and the manufacturer may conscientiously turn out steel of the finest strength and quality, but unless rust is kept from the columns, beams and girders, the strong, safe skyscraper of to-day may become a death-trap a few years hence.

An excuse which might pass muster if only ordinary business risks were involved is utterly inadequate to defend the use of a substitute for red lead.

Thus one sometimes hears an excuse like this: "Yes, I know red lead is the best paint for metals, but what I use is more convenient and I guess it does pretty well."

In the face of what is at stake, it is scarcely conceivable that any responsible man could make two such admissions in the same breath, namely, that "*red lead is the best*," but "*I am using something else*."

Should Steel Imbedded in Concrete be Painted?

It is often asked: Is the imbedding of structural iron or steel in concrete sufficient to prevent the rusting of the metal members, or should the latter be painted before they are surrounded by the concrete?

We have seen in our brief discussion of the nature of corrosion and the remedies for it, that alkaline solutions tend to change the nature of the iron and render it immune to the galvanic influence which produces rusting. It would seem, therefore, that the caustic lime in the cement should itself be the best possible insurance against the decay of the iron imbedded in it. As a matter of fact, what we would expect does take place and *as long as the cement remains caustic* the metal is perfectly immune to corrosion. The difficulty is, the cement does not remain caustic. It absorbs carbonic acid from the air and the caustic lime becomes converted into insoluble carbonate of lime, which is a poor preventer of corrosion.

Protection of the iron by means of the concrete would be possible, also, only as long as there is perfect contact with the metal. This in practice is very difficult to attain or maintain. It is seldom, in the average structure, that voids or open spaces are not present between the iron member and the surrounding concrete. Usually the contact is not perfect at the beginning and the chemical changes caused by the absorption of carbonic acid by the concrete, cause a loosening of the bond between the iron and concrete, even where contact at first was good.

Through these spaces moisture-laden air flows and even water from leaky roofs, scrubbing brushes, water-pipes, drains and steam-pipes seeps down, causing corrosion. For the same reasons, the encasing of structural iron in shaped brick is inefficient to prevent corrosion.

If complete imbedding of the iron or steel in a good non-porous concrete which can be kept caustic is not practicable, the metal members should be painted with red lead before encasing them.

Iron and Steel Bridges

There is no structure which needs the best possible protective paint more than a steel bridge. Whether maintained by a railroad or by the people, represented by their county commissioners or city department, economy of up-keep should be of the utmost interest.

A paint which gives perfect protection to a metal makes a bridge practically permanent, so far as the ravages of the weather are concerned. Its use is therefore economical, no matter how much cheaper the first cost of substitutes may be. Red lead is the only protective paint which has been shown to be an absolute rust preventive.

Gasometers and Stand Pipes

The desire for economy which influences great railroad corporations to use red lead to protect their bridges

In the third test, strips of sheet iron received two coats of the same paints used in the first two experiments and were immersed in water for three months. The amount of rust in each bottle was accurately weighed and calculation was made on the basis of pounds per 1500 square feet.

Again red lead was the only paint out of thirty-seven to come out with a perfect score. There was *absolutely no corrosion* of those strips protected by red lead.

Of the other pigments, deep iron oxide allowed 123 pounds of rust; middle iron oxide, 134 pounds; extra bright iron oxide, 137 pounds; pure graphite, 215 pounds; Indian red (oxide of iron), 227 pounds; ivory black (carbon), 250 pounds; turkey red, 262 pounds; boiled linseed oil, 500 pounds.

Ranging between these at various points were various pigments and mixtures of pigments. They are of no particular interest as no one now seriously recommends any of them. It is interesting, however, to observe that white lead, zinc oxide and lithopone, which are not urged as metal protectives, proved superior to all of the so-called protective coatings except red lead. The latter was in a class by itself, being the only one to protect the iron perfectly.

Mr. Smith also referred to another test he had made two years before in which red lead again was the only paint which allowed no corrosion whatever. It was in perfect condition after two years.

A Five Year Service Test

One of the best field experiments coming to our notice was that made by Mr. R. D. O'Keefe, superintendent of bridges, Port Huron, Mich. To decide what protective paint the city should use, Mr. O'Keefe painted half of one bridge with our pure red lead and the other half with graphite. At the end of five years, the red lead was in perfect condition, the graphite was washed away and the steel was badly pitted and rusted. All the Port Huron bridges are now painted with red lead. Here is Mr. O'Keefe's letter:

PORT HURON, Oct. 18, '06.

Sirs: Five years ago I had the lower part of Military Street Bridge painted with your pure red lead and linseed oil, and the upper part with a graphite paint, for a test, and am pleased to inform you that the red lead is in first-class condition and has kept the bridge from corroding, while the other paint used on the upper part did not give satisfaction as it would not stand the acid which comes from the river. We are going to paint all the other bridges in the city, and am glad to inform you that we will use your red lead and linseed oil for all bridge work.

Yours respectfully,

(Signed) R. D. O'KEEFE,
Sup't of Public Works.

The Proper Care of Metal Before and After Painting

The application of the right paint is the most vital step in the prevention of corrosion, but every other possible precaution should be taken. The following points should be carefully observed.

It is exceedingly important to clean off rust before painting. Rust is an accelerator of rusting. It is also apt to cause the peeling of the paint.

Have the surface to be painted as smooth as possible. It has been observed that brightly polished steel plates which have been scratched, corrode slowly except at the scratches, where they rust rapidly. Structural steel makers may some day realize the importance of this phenomenon and provide structural steel with much smoother surface than now. At present, structural steel is a rough piece of manufacture. Care should be exercised at the mill, however, to produce as smooth and clean a product as possible. Then the responsibility is upon the contractor to keep it so.

The practice of throwing iron and steel members on the ground and allowing them to be covered with dirt and refuse cannot be commended. They should be handled with care and placed on proper supports. As far as possible they should be kept under cover, unless they are to be used within a comparatively short time.

For years the practice of giving structural steel one coat of protective paint before it left the shop held universal sway. Of late, however, the custom has been

The demands made upon the protective coating of vessels are most trying. Not only is the hull in the water, but there is the friction against docks in the landings, the rough usage which the holds receive in the moving of freight and, withal, the exposure to varying atmospheric conditions as the vessel sails from place to place. It is a significant fact therefore that the standard protective coating for vessels both in the fresh water of the Great Lakes and the salt water of the oceans, is red lead. Last coats of other materials are frequently used because of their greater adaptability to decorative demands or because of power, real or fancied, to prevent fouling of bottoms. White lead, either natural or tinted, is necessary for last coats when light tints are desired, and lamp black is excellent if black is preferable to the orange peculiar to red lead.

But custom is pretty well agreed upon red-lead for the coat which goes next to the iron or steel. The reason has already been explained in connection with the protection of these metals in other work. There is no paint which clings to metals so well as red lead.

The best proof of the superiority of red lead-paint for all metal parts of vessels is its general use for that purpose by the United States Government and an overwhelming majority of vessel owners both on the seaboard and on the Great Lakes.

It is an interesting practice among owners of great freighters, especially on the Great Lakes, to mix white lead and red lead for the finishing coats in the holds. This is done to secure the wearing quality of red lead and at the same time the light tint which the white pigment contributes, thus making the dark hold lighter.

How Much Red Lead to the Gallon?

The practice of various architects, engineers, vessel builders and owners, painters, etc., in regard to the formulas used in mixing red-lead paint varies. The United States Navy Department has general specifications which allow about thirty-one pounds of red lead

to the gallon of linseed oil. From this the formulas run both ways, up to thirty-three pounds to the gallon and down to twenty-five pounds to the gallon. Good results are had by all, but it has been seen that one of the great desiderata in a protective paint is richness in pigment as compared to oil. Therefore, it is evident that those who take full advantage of red lead's power to mix well with a small quantity of oil are securing the greatest benefit. Only exceptional conditions really justify the risk of the smaller proportions of pigment sometimes used. We recommend not less than twenty-eight pounds of red lead to the gallon and we consider thirty-three pounds to the gallon as the best for all general purposes.

Laboratory and Field Tests

Among the most conclusive laboratory experiments for the purpose of testing protective paints is that reported in the *Journal of the Society of Chemical Industry* of December 30, 1899, page 1093. It is contained in an address on "Protective Paints for Iron" by Harry Smith, F. I. C., before the Newcastle Section of the Society of Chemical Industry at the Durham College of Science, England.

Perfectly Protected by Red Lead

Three tests were made: (1) Shallow iron dishes were painted with the various paints and filled with water, which was allowed to evaporate. As fast as the water evaporated the dish was refilled. During the three months of this severe test rust was formed on all the dishes *except those protected by red lead*. Those dishes protected by linseed oil alone were the first to corrode and produced the greatest quantity of rust.

In the second test painted plates were exposed to the weather for twelve months. This was a mild test and, with the exception of those coated with oil alone, no great deterioration was observed on any of the plates.

and steel structural work. Of course, most of them are using more or less of other materials all the time in a spirit of investigation. Cheaper paints are being offered continually and the desire for economy dictates that thorough tests shall be made wherever there is reasonable promise of obtaining good results for less money. It is the more remarkable, therefore, that an admittedly high-priced material holds its own against all comers.

The Railroad Companies

The New York Central and Hudson River Railroad Company uses red lead exclusively where no chances are to be taken. Its engineers, under direction of Mr. Noel C. Carpenter, engineer in charge of structures, have made very extensive tests in recent years to determine the relative merits of various materials and have come to the conclusion that nothing is so good for a protective coating as red lead. Consequently, shop coats—the protective paint—on all important structural iron and steel work, whether for bridge or buildings, are red lead. Finishing coats vary according to conditions to be met.

Most of the other large railroads also use red lead for protective coatings.

The Federal Government

The United States Government is a big user of red lead. The Navy Department uses tons annually, while on public buildings of all kinds red lead is specified for the protection of the structural metal work. At the Brooklyn Navy Yard, where a great deal of repairing of ships is done, an officer said: "We find that if a ship has once been painted well with red lead, little is required thereafter but to touch up abrasions in the outer coat. The protective coats of red lead are generally found intact."

Great Lake Fleets

The United States Steel Corporation maintains an immense fleet of big freight ships on the great lakes

for carrying ore and other material. After exhaustive experiments this great corporation has abandoned all other protective paints and is using red lead exclusively. The general superintendent of a company which builds many of the steel corporation's ships says in an autograph letter in our possession: "I consider a thorough application of red lead upon a properly cleaned steel ship (all crevices or indentations that may be caused by pitting or rust being filled in) to be absolutely the best preservative that can be used."

City of New York

The City of New York, whose annual bill for building and maintaining public structures of many kinds is greater than that of many states and some kingdoms, is an important consumer of red lead. Among the recent structures which are attracting public attention are the Queensboro Bridge over the East River at Blackwell's Island (cantilever type), and the new Manhattan Bridge (suspension type). These, as well as the older structures, Brooklyn Bridge and Williamsburg Bridge, are protected by our red lead.

As to Quality in Red Lead

Red lead is not all alike. Some manufacturers, relying upon the excellence of oxide of lead in a general way, do not pay much attention to making their red lead uniform in composition, texture, color, etc. This fact has led many large users of red lead to adopt certain specifications on these points to which they require the material to measure up.

The requirements of the United States Government, Navy Department, are as follows:

"The dry pigment must be of the best quality, free from all adulterants, and contain at least 94 per cent. of true red lead (Pb_3O_4)—equivalent to 32.8 per cent. of lead peroxide (Pb_2O)—, the balance to be practically pure lead monoxide (PbO.) It must contain less than 0.1 per cent. of metallic lead, and be of such fineness

questioned and many architects and engineers are having the steel delivered unpainted. The new idea has much to recommend it—two considerations especially. The first is, that a certain amount of weathering is desirable to rid the iron of mill scale. The other is, that shop coats are generally poorly done by cheap labor and really do more harm than good, because they cover up the evidence of poor work in the matter of cleaning the metal. In case there is no shop coat, the first painting should be done just before assembling begins.

Scale and all other foreign material must be removed before painting. The relative value of the sand-blast, wire-brush and pickling, as methods for cleaning, are discussed elsewhere in this booklet.

Little can be done on a structure toward securing equality of surface conditions—that is, the same composition of metal—but what can be done should be done, and where palpably different conditions exist, such as where wrought iron rivets and bolts are used on Bessemer steel members, extra precaution should be taken with the painting at such points.

No paint is absolutely impermeable to water or to gases. It is therefore worth while to keep the moisture contents of the air as low as possible. This has particular reference to subways, cellars, etc. In exposed structural work, all gutters or pockets in which rain-water might otherwise collect should be made to drain as nearly dry as possible. In subways and viaducts carbonic and other acids are apt to collect. This should be prevented as far as practicable by mechanical or chemical means.

It is very important to protect bridges and viaducts against the salt drippings from refrigerator cars, for the saline solutions are very apt to accelerate corrosion. The same caution should be observed in all other places where salt water is apt to come in contact with painted metal.

Preparing for Painting

Just before assembling begins all parts of the metal which are not to be exposed—that is, those parts which

cannot be cleaned and painted after erection—should be thoroughly cleaned with wire brushes and scrapers and at least two coats of red lead should be applied to these surfaces.

While the use of the sand blast is theoretically a desirable thing, so few contractors are equipped or are willing to use it that the utmost that can be done at present is to insist upon thorough cleaning with wire brushes and scrapers, with the assistance perhaps of the hammer and cold chisel. This cleaning should be done under the proper supervision of a competent inspector. Painting should immediately follow cleaning.

The selection of proper men to do the cleaning is a matter of no small importance. These men should be impressed with the importance of their work, which should be specialized as far as practicable. The habit of contracting for cleaning and painting work together and placing the whole in the hands of the employers of unskilled labor is a cause of much bad work. *As far as practicable, the cleaning should be done separately by men whose direct interest is that of the owner.*

For the cleaning of small articles, pickling in sulphuric acid is an excellent method, care to be taken afterwards to wash the sulphuric acid all off the iron and then to cover the articles with caustic lime until ready to paint. The following method of treatment should give satisfactory results: Dip the articles, if at all greasy, in a hot ten-per-cent. caustic soda solution; then in hot water; then for, say, ten minutes in hot ten-per-cent. sulphuric acid; then in hot water; then in hot ten-per-cent carbonate of soda (soda ash) solution; rinse well in hot water, and pack in slacked lime until time for painting has come. Remove from the lime; wash well with water; brush clean, and dry rapidly. The articles when dry will be ready to paint.

Prominent Users of Red Lead

The railroads of the United States are practically a unit on the use of red lead for the protection of iron

seed oil (Formulas 1 and 2) and two finishing coats. The finishing coats may be of any color desired, and material should be chosen according to circumstances. (See "Finishing Paints," page 31.)

The first finishing coat should be put on somewhat flat or dead, while the final coat should have a full gloss. Care should be especially observed in the proper painting of inaccessible parts before erection.

Subways.—In the painting of iron and steel in subways the same general rule should be observed as for bridges and viaducts (paragraph preceding), except that the bases of all columns and vertical supports should have five coats of paint. The first two coats should be red lead in linseed oil (Formulas 1 and 2). The finishing coats may be as described above for "Structural Iron Work for Buildings," except where a white finish is desired. In such cases the third coat should be of white lead in linseed oil mixed according to Formula No. 9. The fourth coat should be white lead in linseed oil mixed according to Formula No. 10.

If an enamel finish is desired on top of this fourth coat, finish with Formula No. 11.

The bases of columns and vertical supports, for which we have advised a fifth coat, should receive three coats of red lead in linseed oil, the first and third being mixed according to Formula No. 1, the second coat according to Formula No. 2 and the fourth and fifth coats according to the finish desired. (See "Finishing Paints," page 31.)

Decorative Iron Work.—Railings, grilles, fences, fire-escapes and similar metal work should be painted the same as bridges, viaducts and elevated roads. The finishing paint will depend largely on the decorative demands. The first finishing coat should be applied somewhat flat and the final coat with full gloss. Black, dark olive and dark brown are serviceable for finishing coats. Black may be obtained with lamp black, dark olive by using Formula No. 6, and dark brown by using Formula No. 7.

Tin Roofs and Tin Side-Sheathing.—The founda-

tion for a tin roof should be very tight, for the rusting of such roofs usually *begins underneath*, not on top. It would be good practice to lay tin roofing on building paper. Every piece of tin should have one coat of red lead (Formula No. 1) on its under side before being laid.

After thoroughly cleaning to remove the rosin and fluxing materials, the completed roof should receive two coats of protective paint. (Formulas Nos. 1 and 3.) The finishing coat may be a red lead paint with from four to sixteen ounces of lamp black to the gallon (see Formulas Nos. 4 and 7), or any good paint which will give the tint desired. Formula No. 7 gives a rich brown and is very desirable, but in specifying be careful that an iron-oxide paint is not substituted. The latter will imitate the red-lead and lamp-black paint very closely in appearance but is not so durable.

PAINTING GALVANIZED IRON.—Galvanized iron is sheet iron coated with zinc by dipping or by means of galvanic or electric action. The process was invented and is used in an attempt to protect the iron from corrosion. The method is unsatisfactory alone, however, and it is found necessary to paint galvanized iron the same as any other form of the metal.

Its greatest advantage is the fact that it can be soldered and can therefore be used for cornices. Its great disadvantage is that, while it requires painting, it resists paint. Unless very carefully done the best paint will peel from it.

Where practicable it is a good plan to let the galvanized iron weather until it has developed a tooth, then clean the surface with a wire brush. This is frequently impracticable, however, and the following method of preparing the surface is recommended by a great many excellent painters, although our own experiments with it have not been so uniformly successful as to justify a sweeping endorsement:

In one gallon of soft water dissolve two ounces each of copper chloride, copper nitrate and sal ammoniac, then add two ounces of crude hydrochloric acid. This

that not more than 0.5 per cent. remains after washing with water through a No. 21 silk bolting cloth sieve. It must be of good bright color and be equal to the standard sample in freedom from vitrified particles and in other respects."

The American Bridge Company states its requirements as follows: "This red lead must be strictly pure and shall contain at least 80 per cent. of true red lead of the composition Pb_3O_4; the total amount of lead present shall not be less than 89 per cent., of which not more than one-tenth of one per cent. shall be present as metallic lead. The color shall be a clean and pure tint. The red lead shall be of the fineness that when washed with water through a No. 19 silk bolting cloth, not more than one per cent. shall be left on the screen."

The City of New York in its specifications for the new Queensboro Bridge specified as follows: "The red lead must be strictly pure and shall contain at least 90 per cent. of pure red lead of the composition Pb_3O_4; the total amount of lead present shall not be less than 89 per cent., of which not more than one-tenth of one per cent. shall be present as metallic lead. The color shall be a clean and pure tint. The red lead shall be of the fineness that when washed with water through a No. 19 silk bolting cloth, not more than one per cent. shall be left on the screen."

Our red lead easily fulfils these strict requirements, which accounts for its general use by all large and discriminating consumers. We welcome all such tests on the part of buyers and willingly co-operate to obtain the best results possible in the painting of structural steel.

Mixing and Applying the Paint

General Cautions.—Where parts of iron and steel are unusually exposed to corroding or abrasive influences, they should receive extra attention in the matter of painting and preferably an extra coat should be applied to all such places. Thus all bolts, rivet-heads, all

edges and all corners, should have an extra coat of protective paint so that at these points the paint may be thicker than where the surface is simply flat and therefore not subject to especially destructive influences.

All parts in contact should be flushed fully with paint as it is at such points that corrosion is apt to be especially insidious. Engineering construction should provide for the accessibility of all parts for the purpose of painting.

In all cases the application of the paint should be done by competent workmen, using round brushes wherever practicable. The round, pound brush is an excellent type of brush to use.

The paint should be of such thickness as to *require* a strong arm and wrist to brush it out.

STRUCTURAL IRON WORK FOR BUILDINGS.—In buildings, structural iron and steel are generally encased in brick or concrete. We have already called attention on page 15 to the advisability of painting structural iron and steel which is so encased. All such structural metal work should receive three coats of red lead paint, and in addition, such touching up of edges and rivet-heads and bolts as may be necessary to thoroughly protect these especially exposed parts. The first coat should be of pure red lead and linseed oil (Formula No. 1). The second coat should be red lead and linseed oil with an ounce of lamp black in oil added for the purpose of changing the tint. (Formula No. 2.) The third or finishing coat may be a darker red-lead coat, (Formula No. 4), a dark olive (Formula No. 6) or it may be a black coat of finely ground graphite or lamp black (Formula No. 5). The addition of a small percentage of varnish to this finishing coat will improve its quality.

BRIDGES, VIADUCTS AND ELEVATED ROADS.—Structural iron and steel exposed as it is on bridges, viaducts, elevated roads and all similar structures should receive the same treatment as described above for iron work except that they should have four coats instead of three, consisting of two protective coats of red lead and lin-

must be done in an earthen or glass vessel, never in tin or other metal receptacle. Apply the solution with a wide, flat brush.

Steel Ships.—The bottoms of steel vessels, cargo holds, coal bunkers, chain lockers, and in fact all metal parts of vessels, should first be freed from dirt and rust and then be treated with a coat of red-lead paint, mixed according to Formula No. 1. This should be followed, when dry, with a coat of red lead paint to which an ounce of lamp black and oil has been added. (Formula No. 2.) A third coat of pure red lead and oil mixed according to Formula No. 1 should be next applied, unless for any reason a dark shade is desired, in which case any of the finishing paints, recommended under that heading below, may be used.

The interiors of cargo holds and other metal parts of ships should be treated the same as bottoms except that in many cases finishing coats of either lighter or darker hue are desired. The finishing coats spoken of above are available for these purposes. There is another popular treatment now being practiced for the sake of lighting up what would otherwise be a dark place. This is to apply over the red lead coats a coat of red lead mixed with white lead in the proportions of two parts red lead to one of white lead. (See Formula No. 12.) A large number of steamship companies, especially on the great lakes, are using this formula.

Finishing Paints

When iron and steel have had a sufficient number of coats of good protective paint, the problem is to select suitable finishing paints. Generally speaking, any good paint can be applied over a suitable foundation. By good paints we mean paints that, selected as to color for artistic reasons, are reasonably impermeable and contain no actually deleterious constituents. If the paint is to be exposed out of doors, more care should be exercised in the selection of the paint to be used than if the paint is not to be exposed.

It can be considered good practice to have the finishing coat of a color close to that of the original iron: that is, if the two or more protective coats start as red, one or two finishing coats of black paint on top of this would ensure fairly complete protection and covering of the metal. The black paint could not be applied imperfectly without such imperfect application becoming immediately noticed by the showing through of the red protective coatings.

Where the iron and steel are exposed, the kind of finishing paint to use depends upon the color desired.

For railroad bridges and structures similarly exposed, a black paint is to be preferred. For decorative purposes, it is often desirable to use a dark olive. For interior work, enamel paints are sometimes used; in which case, white lead or zinc enamels are to be preferred to those made from lithopone.

A small amount of varnish is sometimes used also in other finishing paints besides enamels. There is no objection to this, as it adds hardness and impermeability to the coat. When such paints begin to decay, however, they are apt to decay with great rapidity and consequently should be watched carefully.

In certain places, such as train sheds, where the color is not important, it has been difficult to obtain satisfactory protection on account of the sulphur in the engine smoke; and in such cases the best protection on record has been obtained by applying, over the wet paint, sheets of thin paraffin paper, subsequently giving this also a coat of paint.

There are so many conditions which determine the kind of paint to be used as a finishing paint that we can simply conclude this phase of the subject by repeating that, when a good foundation paint has been applied to iron and steel, any good paint can be used over it as a finishing paint.

Tints for Finishing Coats

In cases where decoration is important and especially where the painted iron work should be brought into

harmony with the surrounding color scheme, it is very often desirable to use white or light tints. In all such cases pure white lead and linseed oil is the finishing paint to use. These materials make the most durable finishing paint for average conditions and by using with them the proper tinting colors, any desired tint or shade can be obtained.

White lead and linseed oil are especially adapted for use over red lead and linseed oil, because linseed oil dries much the same with these two pigments and therefore the two paints make a homogeneous film, as regards the dried-oil component.

A word of caution should be given upon the use of red lead and lamp black to form a brown. (Formula No. 7.) This gives a color which can be very easily imitated by the brown oxides of iron and care should be exercised that the latter is not substituted for the more durable red lead.

(Formulas referred to will be found on pages 34 and 35. Form of specification in order to secure the highest quality of red lead is given on the inside of the back cover.)

Mixing and Applying the Paint

FORMULAS

Priming and Body Coats

No. 1.—PURE RED LEAD PRIMING COAT.

1 gallon linseed oil; (⅓ boiled oil, ⅔ raw; or all raw oil with ½ pint turpentine drier added.)
33 pounds pure red lead.

No. 2.—RED LEAD COAT, TINTED.

1 gallon linseed oil; (⅓ boiled oil, ⅔ raw; or all raw oil with ½ pint turpentine drier added.)
33 pounds pure red lead.
1 ounce lamp black in oil.

No. 3.—RED LEAD COAT, TINTED.

1 gallon linseed oil; (⅓ boiled oil, ⅔ raw; or all raw oil with ½ pint turpentine drier added.)
33 pounds pure red lead;
2 ounces lamp black in oil.

Finishing Coats

No. 4.—RED LEAD COAT, TINTED.

1 gallon linseed oil; (⅓ boiled oil, ⅔ raw; or all raw oil with ½ pint turpentine drier added.)
33 pounds pure red lead;
4 ounces lamp black.

No. 5.—BLACK COAT.

A good black paint of finely ground graphite or lamp black with a small percentage of varnish added.

No. 6.—DARK OLIVE.

100 pounds pure white lead;
16 pounds French ochre;
46 pounds medium chrome yellow;
19 pounds lamp black in oil.

(This gives the properly tinted pigment. Linseed oil and drier must be added in sufficient quantities to bring it to painting consistency.)

No. 7.—DARK BROWN.

1 gallon linseed oil; (⅓ boiled oil, ⅔ raw; or all raw oil with ½ pint turpentine drier added).
27 pounds pure red lead;
1 pound lamp black in oil.

No. 8.—WHITE GLOSS FINISH FOR EXTERIOR.

3½ to 4½ gallons raw linseed oil;
1 pint pure turpentine;
1 pint pure turpentine drier.
100 pounds pure white lead.

No. 9.—WHITE GLOSS FINISH FOR EXTERIOR.

(Slightly flatter than No. 8.)

2½ gallons linseed oil; (⅓ boiled oil, ⅔ raw oil or all raw linseed oil with ½ pint turpentine drier added.)
1 gallon turpentine;
100 pounds pure white lead in oil.

No. 10.—WHITE FLAT FINISH FOR INTERIOR.

¼ gallon raw linseed oil;
1¾ to 2 gallons pure turpentine;
1 pint pure turpentine drier;
100 pounds pure white lead.

No. 11.—WHITE ENAMEL FINISH FOR INTERIOR.

1 gallon light enamel varnish;
3 pounds pure white lead.

(Break up the white lead first with a little turpentine to a thick paste, then mix well with the varnish.)

No. 12.—SHIP HOLD FINISH.

1 gallon linseed oil; (⅓ boiled oil, ⅔ raw; or all raw oil with ½ pint turpentine drier added.)
22 pounds pure red lead;
11 pounds pure white lead.

NOTE—The formulas for white finishes can be adapted to any tint desired by putting in the proper tinting material and adding thinners equal to one-half the weight of the tinting material.

NOTE—When red lead is mentioned in these formulas, dry red lead is meant. On the contrary, when white lead is mentioned, white lead-in-oil, as usually furnished to the trade, is meant.

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When specifying paint for metals name

"SOUTHERN
Pure Red Lead
and pure linseed oil"

or

"NATIONAL LEAD CO'S
Pure Red Lead
and pure linseed oil"